BAKER (H. B,)

RELATIONS OF CERTAIN METEOROLOGICAL CONDITIONS TO DISEASES OF THE LUNGS AND AIR PASSAGES AS SHOWN BY STATISTICAL AND OTHER EVIDENCE.*

CONNEXITÉ DE CERTAINES CONDITIONS MÉTÉOROLOGIQUES AVEC LES MALADIES DES POUMONS ET DES VOIES RESPIRATOIRES COMME LE DÉMONTRENT LA STATISTIQUE ET D'AUTRES ÉVIDENCES.

ÜBER DIE BEZIEHUNGEN GEWISSER METEOROLOGISCHER ZUSTANDE ZU DEN KRANKHEITEN DER LUNGE UND LUFTWEGE, WIE SIE DURCH STATISTISCHE UND SONSTIGE BELEGE ERWIESEN.

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One of the reasons for the presentation of this paper is the possibility of bringing forward a kind of evidence not usually obtainable, namely, statistics of sickness over wide areas, and the comparison of those statistics with statistics of the principal meteorological conditions antecedent to and coincident with the sickness. Another reason is the belief of the writer that he has learned some of the reasons why the rise and fall of diseases of the lungs and air passages are, ordinarily, controlled by the temperature and other conditions of the atmosphere. Before stating the reasons why, however, it may be best to make sure that the fact is established that the rise and fall of certain diseases are ordinarily controlled by meteorological conditions. For this purpose I present several diagrams, accurately drawn to scale and based upon statistics carefully and conscientiously compiled; and I ask attention especially to a diagram (No. 4) showing a comparison of over 30,000 weekly reports of sickness, during the eight years 1877-84, with over 150,000 coincident observations of the atmospheric temperature—from which it may be seen that the rise and fall of the sickness from pneumonia in Michigan follow absolutely the fall and rise of the atmospheric temperature. The sickness is reported each week so long as it continues. I believe that is one reason why the line representing sickness from pneumonia follows uniformly later than the line representing temperature. It should, on that account, follow later by a time equal to the average duration of the disease. But if caused in the way I point out, it should follow later, also because the condition which permits the exudation of the albuminous constituents of the blood into the air cells requires, for its production, the continuance of the effects of the inhalation of cold air.

That pneumonia may sometimes result from a sudden and short exposure to cold is not here denied, but it is affirmed that, as a rule, the previous exposure to the inhalation of cold air for a considerable time had prepared the lungs to be thus affected. (This may be more apparant further on.)

The fact that the curves for influenza, tonsilitis, bronchitis and pneumonia are, in general outlines, all practically the same, seems to me strong proof that the controlling cause is one and the same for all these diseases. They are diseases of the air passages, and may be supposed to be influenced or controlled by the atmosphere. The atmospheric conditions which I have found to stand in such relation to all of them as to make it possible that they

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have causal relation, are the temperature, the absolute humidity, the daily range of pressure and the ozone. Of these conditions the temperature of the atmosphere seems to me to be probably the most important causal condition controlling these diseases. I believe that a large share of its control is through its control of the humidity of the air, and this point I hope to make plain.

ORDER OF SUCCESSION OF SOME OF THE COLD-WEATHER DISEASES.

I have proved that in Michigan the rise and fall of sickness from pneumonia follow quantitatively the fall and rise of the atmospheric temperature. This is apparent from a diagram (No. 4) which I present. I have shown by diagram (No. 3) that the rise and fall in the sickness from bronchitis, in Michigan, follow the fall and rise of the atmospheric temperature, although not so precisely quantitatively as is the case with pneumonia. By examining the evidence in these two diagrams, it may be seen that throughout the year an average of about forty per cent of the weekly reports stated that pneumonia was under observation, while an average of about sixty per cent of the reports stated that bronchitis was observed. It follows that among persons throughout the State exposed to the same atmospheric temperature, many more are taken sick with bronchitis than with pneumonia. It may also be seen that, as the cold weather approaches in the autumn, bronchitis increases more rapidly than pneumonia, also that it lingers longer in the spring months than does pneumonia. All these facts harmonize if we suppose that a less exposure to low temperature is ordinarily required to produce bronchitis than to produce pneumonia.

In Michigan the sickness from influenza, tonsilitis, croup, diphtheria and scarlet fever, follows more or less closely the fluctuations of atmospheric temperature. It seems necessary to explain how it is possible for a cold atmosphere to cause in one person influenza, in another tonsilitis, in another croup, while in others it favors the contraction of a contagious disease like scarlet fever.* It is probable, however, that the explanation would have been easy long ago except for a misapprehension of one of the principal facts. It has generally been stated that when these diseases were favored by a cold atmosphere, the air was not only cold but damp; and just how cold alone could do so much, or how dampness could favor the production of one of these diseases, has never been explained, notwithstanding the fact that dampness renders the cold more apparent and perhaps more effective. But the fact which has been lost sight of is that cold air is always dry air, absolutely; it is only the relative humidity or percentage of saturation of the air that is great when the air is cold. This is made plain by the study of any table of the absolute humidity showing saturation of air at different temperatures; thus a cubic foot of air at zero Fahrenheit cannot contain more than one-half grain of vapor of water; at 32° F. it cannot contain more than two grains; while at 70° it may contain eight grains, and at 98° F., which is near the temperature of the air passages, each cubic foot of air may contain 18.69 grains of vapor. The influence of cold dry air in the production of "chapped" hands has probably been noticed by most persons, and the stopping up of the nose by drying must have been often observed early in the occurrence of common colds, as also the dry cough which so commonly calls for some medicine to "loosen the cough." But the drying effects of the inhalation of

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*In a paper entitled "Some of the Cold-weather Communicable Diseases," published in the *Transactions* of the Michigan State Medical Society for 1887, I have shown that the curves for scarle fever, diphtheria and small-pox follow the inverted curve for temperature.

cold air can best be understood by reflecting that each cubic foot of air inhaled at zero F. can contain only one-half a grain of vapor, while when exhaled it is nearly saturated at a temperature of about 98° F., and therefore contains about 18.69 grains of water, about 18 grains of which has been abstracted from the air passages.

Coryza.—Thus, cold air falling upon susceptible nasal surfaces tends to produce an abnormal dryness, which may go so far as to cause the "stopping up" of the nose, which may be followed by suppuration. In my opinion a common cold or coryza may thus be caused.

Influenza.—In some persons, under some circumstances, the nasal surfaces may not be susceptible to drying, that is to say, fluids may be supplied in increased quantity to meet the increased demand by the cold dry air, in which case the constant evaporation of the fluids will lead to an abnormal local accumulation of the non-volatile salts of the blood, such as sodium chloride, which is an irritant; and what is termed influenza may then arise. The close relations of influenza and atmospheric temperature are shown in the diagram (No. 1) which I submit herewith. It may be seen that influenza increases promptly in the summer and autumn, as soon as cold weather begins—more promptly than bronchitis or pneumonia does. This order of succession might be expected if these diseases are all caused in the manner pointed out in this paper; but it may, in part at least, be due to the shorter average duration of influenza.

Bronchitis.—The effects which the inhalation of cold dry air have upon the bronchial surfaces will depend greatly upon how the upper air passages respond to the increased demand for fluids; because if they do not supply the moisture the bronchial surfaces will certainly have to sustain an increased demand, in which case, as the phrase is among the common people, a "cold in the head" may then "settle on the lungs," and the person may have bronchitis. The bronchitis which results from the inhalation of cold dry air may be of that sort (like a cold in the head) characterized by an abnormal deficiency of the fluids, at least in the beginning of the disease, or it may be of that sort (like influenza) which is characterized by an excess of fluids, in which case, if the exposure is continued, the evaporation which results from the inhalation of air unusually cold and dry necessarily leads to the abnormal increase in that fluid of the non-volatile salts of the blood.

Pneumonia.—Bronchitis not infrequently precedes pneumonia. The most distinctive feature of lobar pneumonia is the exudation. Certainly the causation of pneumonia is not explained until the manner in which the exudation is caused has been made plain. In papers on the causation of pneumonia I have elsewhere pointed out how such an exudation should be expected to result, in accordance with known laws of osmosis, from long-continued exposure to the inhalation of cold dry air. Since 1850, when Dr. Redtenbacher published his observations,* it has been known that during the onward progress of pneumonia chloride of sodium is absent from the urine; and since 1852 it has been known, through the researches of Lionel Smith Beale, † of London, England, that the chloride of sodium, which then disappears from the urine of a pneumonia patient, may be found in the sputa and in the solidified lung. I have shown ‡ that during the inhalation of cold dry

* *Zeitschrift der k. k. Gesellschaft der Aerzte zu Wien* Aug., 1850.

† Vol. XXXV, Medico-Chirurgical *Transactions*, published by the Royal Medical and Chirurgical Society, London.

‡ *Transactions* of the American Climatological Association, May 10, 11, 1886, pp. 226-233. Also, *Proceedings* of Michigan State Board of Health, Oct., 1886, pp. 7-11.

air the quantity of fluid which passes out from the blood vessels into the air cells must be increased in order to meet the increased demand, and that through the increased evaporation an increasing quantity of the non-volatile salts of the blood may accumulate in the air cells. In connection with the foregoing, I have also pointed out that as soon as the proportion of sodium chloride reaches about three or four per cent. of the fluid in the air cells, the albuminous constituents of the blood should begin to pass out into the air cells.* And thus the chain of explanation of how the exudation which occurs in croupous pneumonia is caused, seems to have been completed.

The law of osmosis, in accordance with which albuminous exudations occur whenever the fluid exterior to the blood vessels contains about four per cent of sodium chloride, probably applies, as a rule, to exudations throughout the air passages, and so I will not repeat it in connection with coryza, influenza, tonsilitis, croup and bronchitis. Indeed, the law probably applies in all diseases and throughout the human body; but it seems probable that there are other conditions which favor the exudation of the albuminous constituents of the blood, such conditions, for instance, as cause a breaking down or change in the albuminous constituents themselves, variation in the blood pressure through variations in the atmospheric pressure; and it is not difficult to see that blood pressure may be increased locally, as, for instance, through disturbed action of the heart, and, finally, an important factor in the causation of pneumonia and of exudation throughout the air passages, is undoubtedly the more or less complete paralysis of parts directly exposed to unusual cold, which may subsequently occur on their being subjected to warmth.

Bearing upon the subject of the influence of atmospheric pressure in favoring pneumonia, I submit a diagram (No. 7), which shows that, in Michigan, the curve for the average daily range of atmospheric pressure coincides very nearly with the reversed curve for the temperature, and that the sickness from pneumonia follows it somewhat closely, but not as closely as it does the temperature, perhaps, however, because the statistics relative to pressure do not cover sufficient time to obtain a correct average.

My researches appear to prove that pneumonia, whether croupous or catarrhal, seems to be controlled by the atmospheric temperature. It, therefore, seems true, as many have long believed, that for both forms the causation is similar. From my standpoint it seems possible that in the catarrhal form the sodium chloride in the fluid which moistens the air cells, does not reach or much exceed the three or four per cent, which is required in order that the ordinary albuminous constituents of the blood should begin to pass out into the air cells, as it does in croupous pneumonia. It also seems possible that lobar pneumonia may require for its production that partial paralysis which results from the experience of a warm atmosphere immediately following exposure to cold (such an effect as is seen in the flushed cheek of a person brought into a warm room from extreme cold outer air), in which case the exudation should occur in just that part of the lungs supplied by the

*"But a substance like albumen, which will not pass out by exosmosis toward pure water, may traverse a membrane which is in contact with a solution of salt. This has been shown to be the case with the shell membrane of the fowl's egg, which, if immersed in a watery solution containing from three to four per centum of sodium chloride, will allow the escape of a small proportion of albumen. Furthermore, if a mixed solution of albumen and salt be placed in a dialysing apparatus, the salt alone will at first pass outward, leaving the albumen; but after the exterior liquid has become perceptibly saline, the albumen also begins to pass in an appreciable quantity." John C. Dalton, "Treatise on Human Physiology for use of Students and Practitioners," etc., Philadelphia, 1875, p. 363.

nerve influenced by the cold, because the walls of the blood vessels of just that part should be relaxed. The chill may result from such a disturbance of the nervous equilibrium, and be in the nature of an attempt to regain control of the relaxed blood vessels.

Elsewhere* I have shown—and it may be seen by diagrams 8 and 9—that a few communicable diseases, which, as a rule, gain access to the body through the air passages, are quantitatively related to the atmospheric temperature, almost invariably rising after the temperature falls, and falling after the temperature rises. The explanation has seemed to me to be that those exudations which result from the inhalation of air colder than usual supply a *nidus* for the reception and reproduction of the specific contagia of scarlet fever, small-pox, etc.

Inasmuch as diseases known to be contagious follow so exactly the fluctuations of atmospheric temperature, that pneumonia is also controlled by the temperature is no proof of the non-contagiousness of pneumonia; but all, or nearly all, of the phenomena of pneumonia are now accounted for without reference to a special contagium, and the same can be said of bronchitis, influenza and the other diseases of the upper air passages.

BEARING UPON DIET AND TREATMENT.

If, as I believe, nearly all of the diseases of the air passages, and some contagious diseases which gain entrance to the body through the air passages, are associated with unusual evaporation of fluids from their surfaces, and the accumulation there of the non-volatile salts of the blood which act as irritants, and which, when in sufficient quantity, cause the exudation of the albuminous constituents of the blood, these facts have an important bearing upon the subject of diet best adapted to freedom from these two classes of diseases; for it is obvious that in a person whose blood is strongly saturated with sodium chloride or other fixed salt, the exudations may be quite different from those in a person whose blood is only scantily supplied with fixed salts.

If these views are found to be correct—namely, that trouble comes from the accumulation of the non-volatile salts in the air passages—they may help to explain why in practice a volatile salt, like ammonia, has sometimes been preferred to a salt of a fixed alkali, and why such a volatile substance as carbonate of ammonia has been preferred by some as even more satisfactory than the chloride of ammonium in the treatment of certain acute affections of the air passages.

The importance of ascertaining the controlling causes of this large class of diseases seems to warrant analyses of the fluids transuded in influenza and in bronchitis, and such other experiments by those who have opportunity as shall prove or disprove the views here set forth.

PREDISPOSING CAUSES—HYPERINOSIS AND PNEUMONIA.

Chemically, fibrin is oxidized albumen. It should not, therefore, be difficult to infer the direction in which we must search for the causation of hyperinosis, namely, in the direction of the causation of abnormal oxidation

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* "Some of the Cold-weather Communicable Diseases," in *Transactions* of the Michigan State Medical Society, 1887.

of the blood. This condition of the blood occurs in pneumonia, in rheumatism and in certain other diseases, and is believed by some to constitute an inflammatory condition of the blood—a tendency toward inflammation. Thus in Aitken's "Science and Practice of Medicine," Vol. II, page 508, Dr. Parkes is quoted as saying: "That hyperinosis is really anterior in pneumonia as in rheumatism, must, in spite of the opinion of Virchow, be considered likely from experiments, among others, of Prof. Naumann, of Bonn." It is conceivable that abnormal oxidation of the blood serum may result from an abnormal proportion or activity of the red blood corpuscles. In the same paragraph quotation from Dr. Parkes it is said: "It is well known how frequently the liver is affected in pneumonia, so that some amount of jaundice is not at all uncommon, and sometimes bile pigment appears in the pneumonic sputa. I have also found in some cases evidence of liver affection for some time before the lung disease, especially the so called torpor with deficient biliary flow." * Whenever the production of red corpuscles continues at the normal rate, and they are not destroyed in the liver as fast as they normally are, it would seem that their accumulation may favor excessive oxidation of the albuminous constituents of the blood serum, in a condition described by the word hyperinosis. But it is still more conceivable that abnormal oxidation of the blood serum may result from the inhalation of oxygen in greater than normal amount, or in a condition of unusual activity, and ozone is oxygen in such an active condition. Furthermore, the curve for the rise and fall of atmospheric ozone is, in Michigan at least, almost precisely the curve for the rise and fall of pneumonia. (It is probable, however, that the quantity of residual atmospheric ozone is controlled by the atmospheric temperature.) It may be added, also, that the late Dr. Henry Day, of London, England, claimed that his experiments with dogs proved that the inhalation of ozone caused bronchitis, and in larger quantities, pneumonia.

While, therefore, I do not claim that atmospheric ozone is the sole cause of pneumonia, it seems quite probable that it may be a cause of hyperinosis, which is apparently a predisposing cause of pneumonia and of other diseases. It seems reasonable to believe also that an exudate, which under other conditions would be readily reabsorbed or taken away by the lymphatics as rapidly as formed, may, under the influence of the abnormal oxidizing action of ozone become too insoluble to be thus disposed of, and consequently accumulate as the fibrinous exudate in pneumonia, in pleuritis, in croup, etc., and also serve as a *nidus* for any contagium inhaled.

In Michigan the curves for sickness and for deaths from pulmonary consumption seem to follow irregularly the inverted temperature curve, about one to three months later in time. Consumption thus seems to be influenced by the same meteorological conditions as is pneumonia. In this connection and in connection with what has been said as to the difficult removal of oxidized exudates, it is worthy of notice that Dr. H. F. Formad, of Philadelphia, has claimed that a structural condition predisposing to consumption is abnormally few and narrow lymph spaces in the connective tissues.† All of these alleged facts seem to be in harmony with what I have suggested as to the

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* Aitken's "Practice," Vol. II, p. 508.

†"Tuberculosis usually ensues when a simple inflammation is set up by any kind of injury, in animals with the structural peculiarities that I have described; but tuberculosis cannot be produced in animals which do not have this structural peculiarity, so far as my experiments show, unless the injury is inflicted upon serous membranes."—*Journal of American Medical Association*, Vol. II, p. 148.

fibrinous *nidus* being the controlling cause of certain communicable diseases which enter through the air passages.

Pulmonary Consumption.—But with a contagium which enters the body, but not through the air passages, if it is capable of entering the general circulation it is probably capable of passing from the circulation to any exudate; so the formation and especially the retention of such an exudate in the lungs and air passages would be expected to supply the conditions for the rapid multiplication of any such contagium. In this connection I submit a diagram (No. 11) showing that in Michigan the sickness reported from pulmonary consumption follows the inverted temperature curve with considerable regularity, except that in the summer and autumn months it is separated from the temperature by a shorter period of time than it is in the winter and spring. The sickness under observation (which includes old cases) will be lessened by the deaths, and this should be especially noticed when the conditions favoring deaths do not also equally favor the production of new cases, as may be the fact on the approach of warm weather. However it may be, the curves for deaths need to be studied. I regret that the deaths in Michigan are not all reported, and the omissions are greater in the earlier months of each year; but in a diagram which I have prepared, it may be seen that after making a correction for the omissions (estimated by comparison with census statistics) the curve for deaths is somewhat similar to the curve representing sickness. Relative to deaths, however, more satisfactory evidence is presented to you in the diagram (No. 10), representing the relation of the deaths from phthisis in London, England, during thirty years, from which it is plain that the curve for deaths from phthisis follows the inverted temperature curve with great regularity.

Returning now to the curve for sickness from consumption in Michigan (Diagram 11): If in the summer months the reduction of the sickness by reason of the deaths is as great as the reduction by reason of the warmer weather, the curve for sickness should show, as it does, a more than average decrease, in fact, a double decrease after the great death rate, which culminates in April; but this double decrease will soon change to less than average decrease, and then, as soon as there is an increase in sickness to more than average increase, culminating at the time of least deaths—which, in Michigan, seems to be in October, but in London is unmistakably in September—then, as the deaths increase, the sickness under observation (old cases and new cases) should not increase as fast as it otherwise would. This may serve to explain why the curve for sickness drops from its maximum in April to its minimum in August in four months, while it occupies double that number of months in going from its minimum to its maximum, which it does not reach until April, but which it might reach in March if the great number of deaths then did not keep it down.

WHAT IS PROVED?

It is useful to "take account of stock," as the merchants do at the close of the year, and ascertain just what is the state of our knowledge. In science I understand that a proposed mode of causation is considered proved when (1) it is demonstrated that the cause assigned is a *vera causa*—a true cause, capable of causing the phenomena ascribed to it; (2) that the cause assigned is present and acting, and (3) that no other known cause capable of causing the

phenomena is present and acting. That chloride of sodium in strong solution is an irritant and a poison is a well-known fact, and the mode of death of animals poisoned therewith has been made the subject of experimental study.* That whenever a fluid containing a non-volatile salt is evaporated there is left a residue of salt, is now a part of our most common knowledge; this is implied by the term "non-volatile." That the blood serum and the fluids of the human body contain non-volatile salts has been demonstrated by many analyses. That the quantity of vapor of water which air can contain is dependent upon the temperature is one of the most well-known facts in meteorology, and that raising the temperature of air increases its capacity for moisture is equally well known. When cold air, which can contain only a small quantity of vapor of water, enters the air passages, and before it is exhaled is warmed, so that it can contain a large quantity, and is constantly in contact with moist membranes, from which it can take vapor of water—that it should take the moisture, and leave a residue of non-volatile salts, is in accordance with all our knowledge and experience on this subject. Finally, in pneumonia the increased non-volatile residue has actually been found, by analyses, in the sputa and in the solidified lung.†

It seems to be demonstrated that the alleged evaporation of fluids containing non-volatile salts takes place, and that the salt is "present and acting" in the air passages. (It does not change this fact if we admit that, normally, the residue left by evaporation is constantly reabsorbed or removed through the lymph channels; because it is possible that, when formed faster than normal, the lymph channels are not capable of removing the residue, or, if removed through them, the irritation may cause œdema sufficient to close those channels.‡)

Considering that the temperature of the air exhaled from the air passages is always nearly the same, it would appear that the residue of non-volatile salts in the air passages should be quantitatively related to the temperature of the air inhaled—that is, to the temperature of the atmosphere. That the sickness from several diseases of the air passages is quantitatively related to the temperature of the atmosphere is demonstrated by the statistics which I have presented. I know of no cause, other than the one I assign, capable of causing the irritation of the air passages, so as to control the rise and fall of coryza, influenza, tonsilitis, croup, bronchitis, pneumonia, and apparently also pulmonary consumption. For myself, therefore, it is proved (1) that the cause assigned is a true cause; (2) that it is present and acting when these diseases are caused, and that it is not only qualitatively but quantitatively related to these diseases; (3) that no other known cause is present and acting, even if we refer to each disease singly, and much less is there present any other known or alleged cause capable of inducing all of these diseases.

It has been objected that it has not been proved that evaporation from the air passages extends to "parts so remote from the outer air as the pulmonary alveoli."§ While it may be difficult to demonstrate this experimentally, I submit that it is susceptible of proof, as follows: Pneumonia rises and falls

* By B. J. Stokvis. In *Archiv für Experimentelle Pathologie und Pharmakologie, Band* 21, *Hefte* 2, *und* 3, *Seite* 170-218.

† By Lionel Smith Beale. *Transactions* Royal Medical and Chirurgical Society, London, England, 1852, Vol. xxxv, pages 325-375.

‡ Interesting in this connection are the researches of Dr. H. F. Formad, of Philadelphia, which, he claims, prove that few and narrow lymph spaces in the connective tissue constitute a structural predisposition to tuberculosis.—*Journal of American Medical Association*, Vol. ii, page 148. And in *Archiv für Experimentelle Pathologie und Pharmakologie*, Dr. Stokvis has shown that animals fatally poisoned by sodium chloride invariably have œdema of the lungs.

§ *New York Medical Journal*, Aug. 13, 1887, page 186.

in relation to the atmospheric temperature in ways similar to those of the diseases of the upper air passages; if the diseases of the *upper air passages* are due to a non-volatile residue left by excessive evaporation, there is no other known cause "present and acting" to account for the pneumonia which is coincident therewith. Furthermore, the increased non-volatile residue having actually been found, by analyses, in the sputa and in the solified lung of the person dead from pneumonia,* this alone amounts to nearly complete proof that the evaporation occurred, because (1) the evaporation of the fluid containing it is known to leave such a residue, and (2) there is no other known cause of the abnormal accumulation there of such a residue as the chloride of sodium Finally, to assume that evaporation of moisture does not extend to the pulmonary alveoli is to assume that the air inhaled reaches its highest temperature before it reaches the alveoli, and that it is fully saturated with moisture at that highest temperature before it reaches the alveoli, neither of which assumptions is probably true, because the air comes most nearly in contact with the warm and fluid blood in the alveoli themselves.

There may be no necessity for any further attempt to account for the fibrinous or albuminous exudations which occur in some or all of these diseases; the irritation by an abnormal proportion of non-volatile salts may be sufficient; but the fact that albumen will pass to a four per cent solution of sodium chloride may well be kept in mind in connection with this subject.

I consider it proved, then, that the rise and fall of the diseases of the air passages are controlled by the atmospheric temperature, and that this is accomplished mainly through the quantity of vapor of water abstracted from the air passages. At the same time the mere evaporation of the water is probably harmless except it leaves an abnormal residue of non-volatile salts, which probably it may most readily do in persons whose blood is abnormally saturated with such non-volatile salts as usually pass out by way of the kidneys, and of which sodium chloride may be named as an example.

THE READING OF THE DIAGRAMS.

For the convenience of those who use the following diagrams, it may be stated that they are to be read with reference to the figures in the right and left hand margins, the numbers indicating the temperature being on the right and those representing the sickness or deaths, as the case may be, on the left. Thus, in Diagram No. 1, it will be seen that in the month of January, the average atmospheric temperature for ten years was 20.56°, and in the same month the average percentage of reports which stated the presence of influenza was 55. In February the average atmospheric temperature was 23.62°, the percentage of reports stating the presence of influenza was 61. In August, when the curves for atmospheric temperature and sickness both reached their lowest point (the curve for temperature being reversed), the percentage of reports stating presence of influenza was 21, while the average atmospheric temperature was 68.14°.

As an illustration, the table giving by months the average atmospheric temperature and the influenza (from which Diagram No. 1 is constructed) is given herewith:—

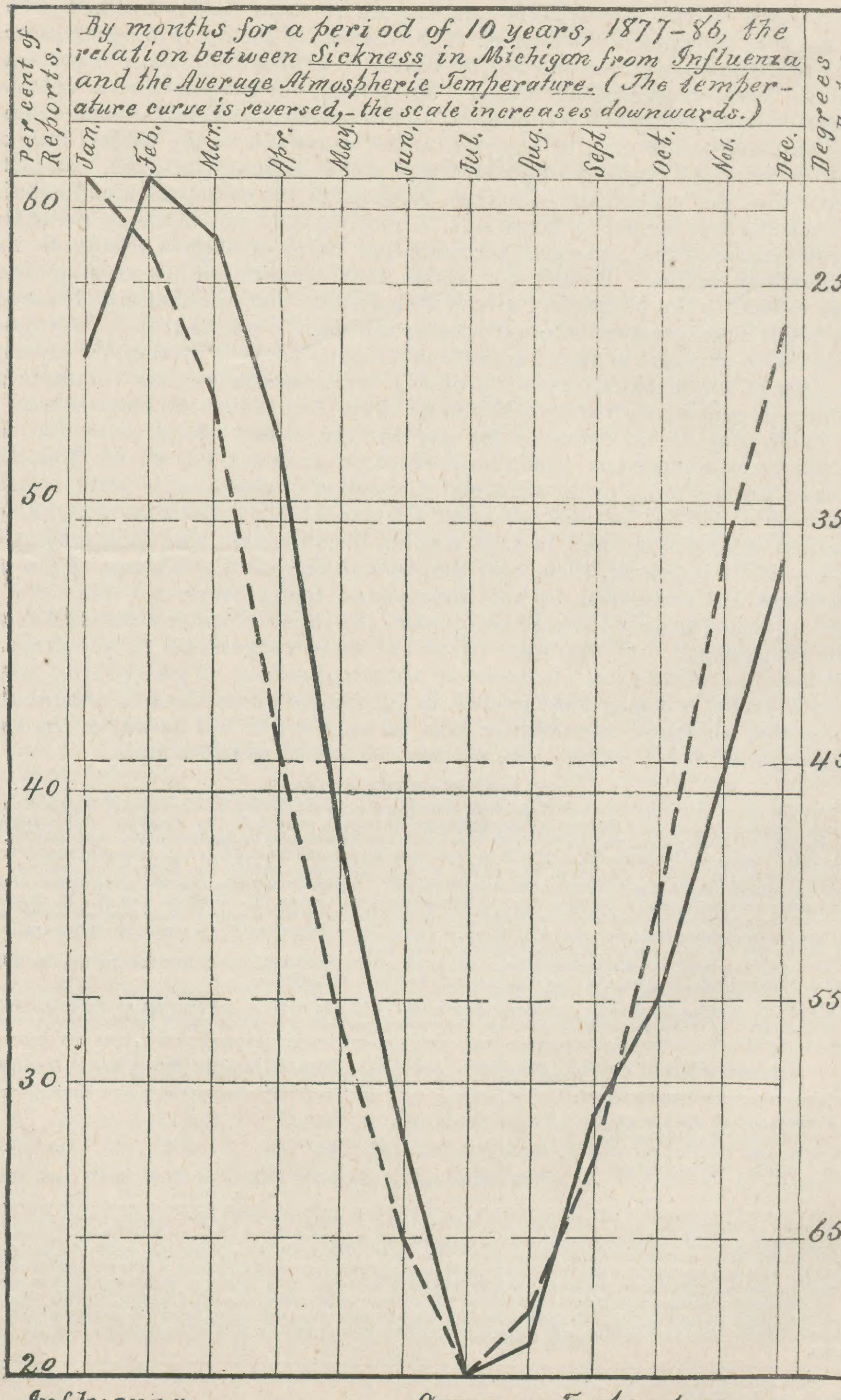
TABLE 1.—*Stating, by months, for the ten years, 1877-86, the average percentage of reports stating the presence of influenza in Michigan, also the average atmospheric temperature for the same period.*

Ten years, 1877-86.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Percentage of weekly reports stating presence of influenza	55.	61.	59.	52.	38.	28.	20.	21.	29.	33.	41.	48.
Av. atmos. temp., degrees Fahr.	20.56	23.62	29.80	44.33	56 08	65.10	70.52	68.14	61.67	50.83	36.04	26.60

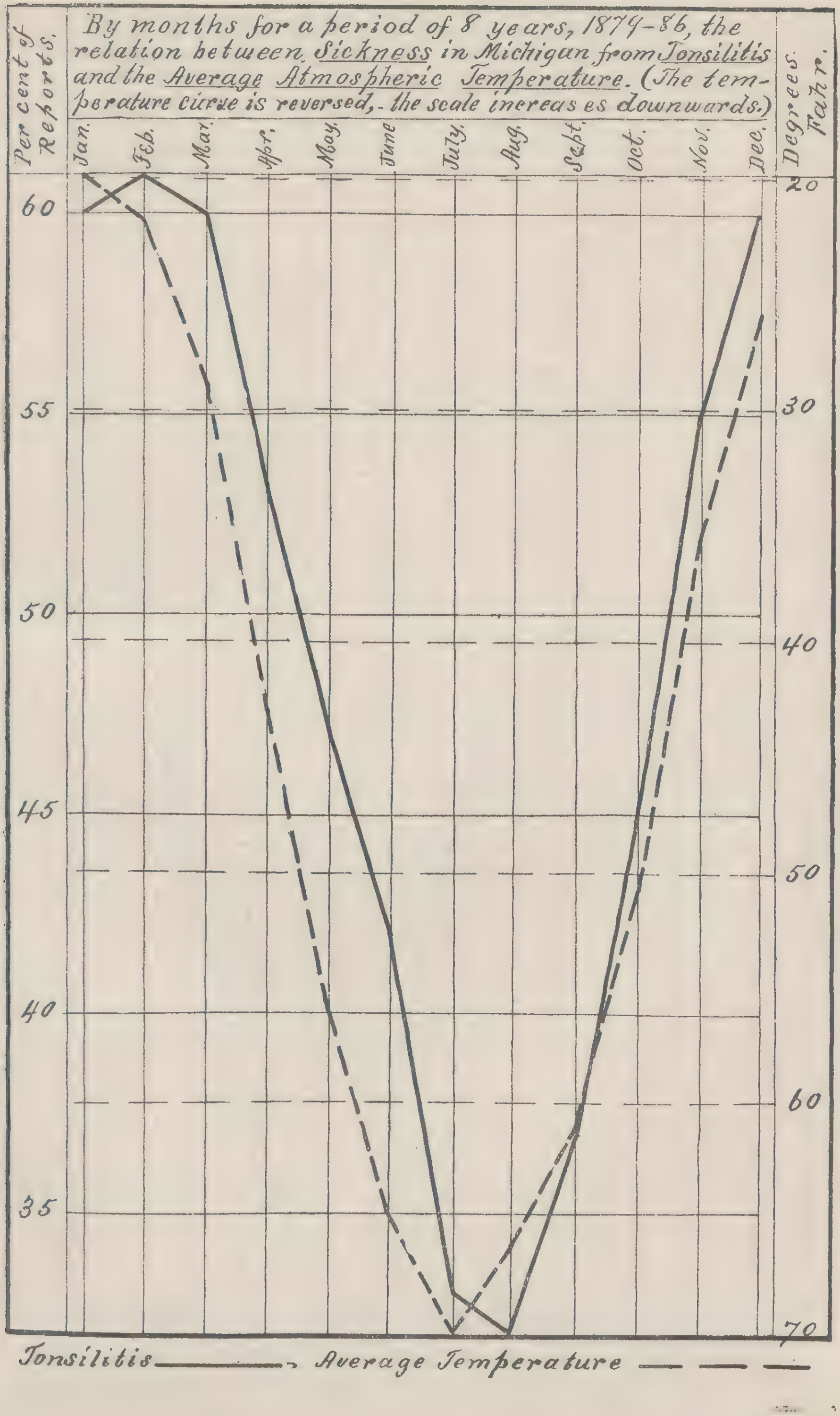
For an exact reading of the figures, the tables which accompany the paper should be studied; but the relations of the temperature in one month to the sickness in that month or in a succeeding month can best be seen from the diagrams. In these diagrams, in which the unit of time is one month, and the curve representing sickness is made from reports of all cases under observation, old cases as well as new cases, the sickness curve should coincide with a curve representing a controlling cause of that sickness if the duration of the disease is less than one-half month, and the disease has no period of incubation, otherwise the curves may be separated by an interval corresponding, as nearly as the long unit of time will permit, to the average duration of the incubation and the sickness.

* By Lionel Smith Beale. *Transactions* Royal Med. and Chirurg. Soc., London, England, 1852, Vol. XXXV, pages 325-375.

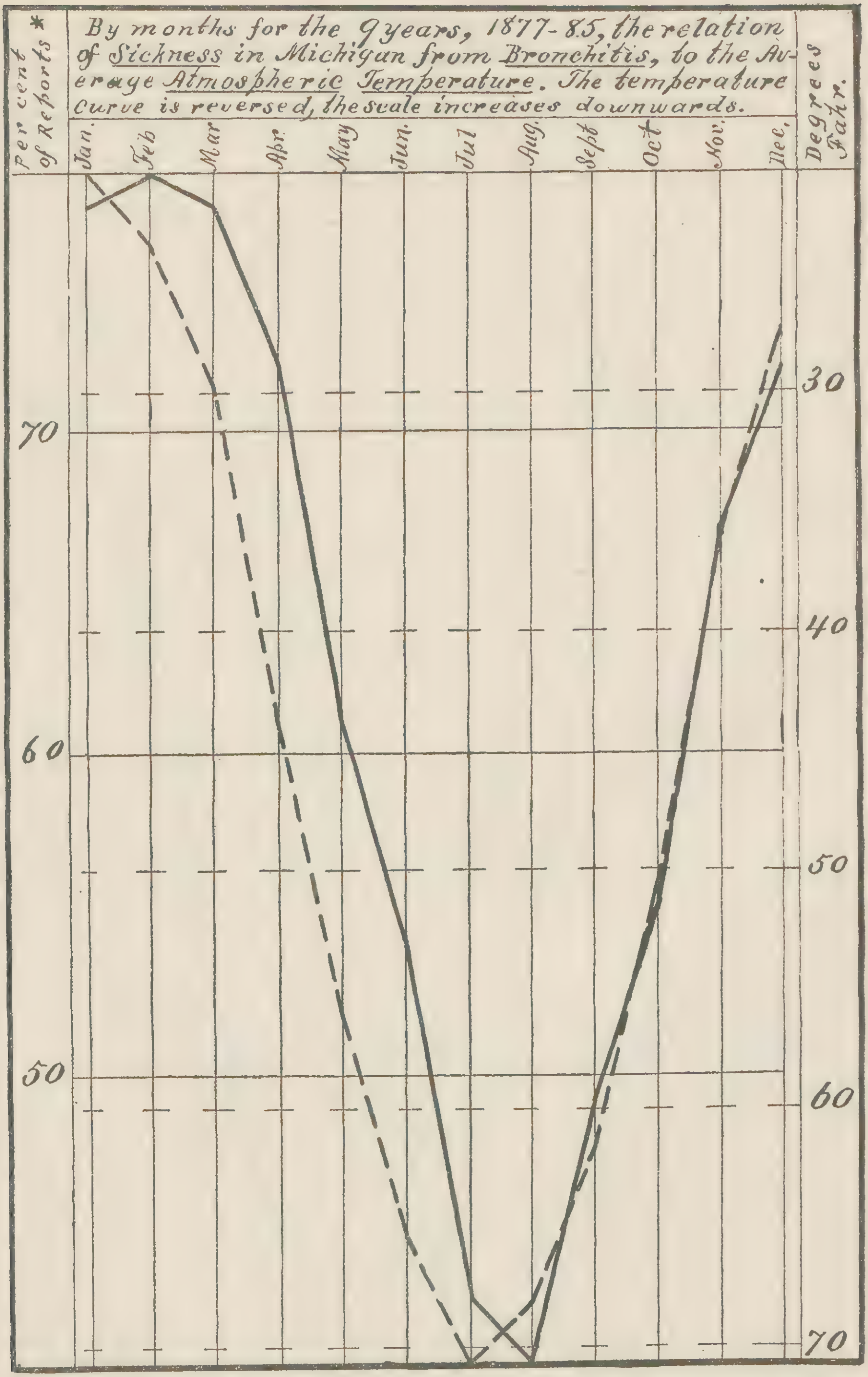
NO. 1.—TEMPERATURE, AND SICKNESS FROM INFLUENZA IN MICHIGAN.



NO. 2.—TEMPERATURE, AND SICKNESS FROM TONSILITIS IN MICHIGAN.



NO, 3.—TEMPERATURE, AND SICKNESS FROM BRONCHITIS IN MICHIGAN.

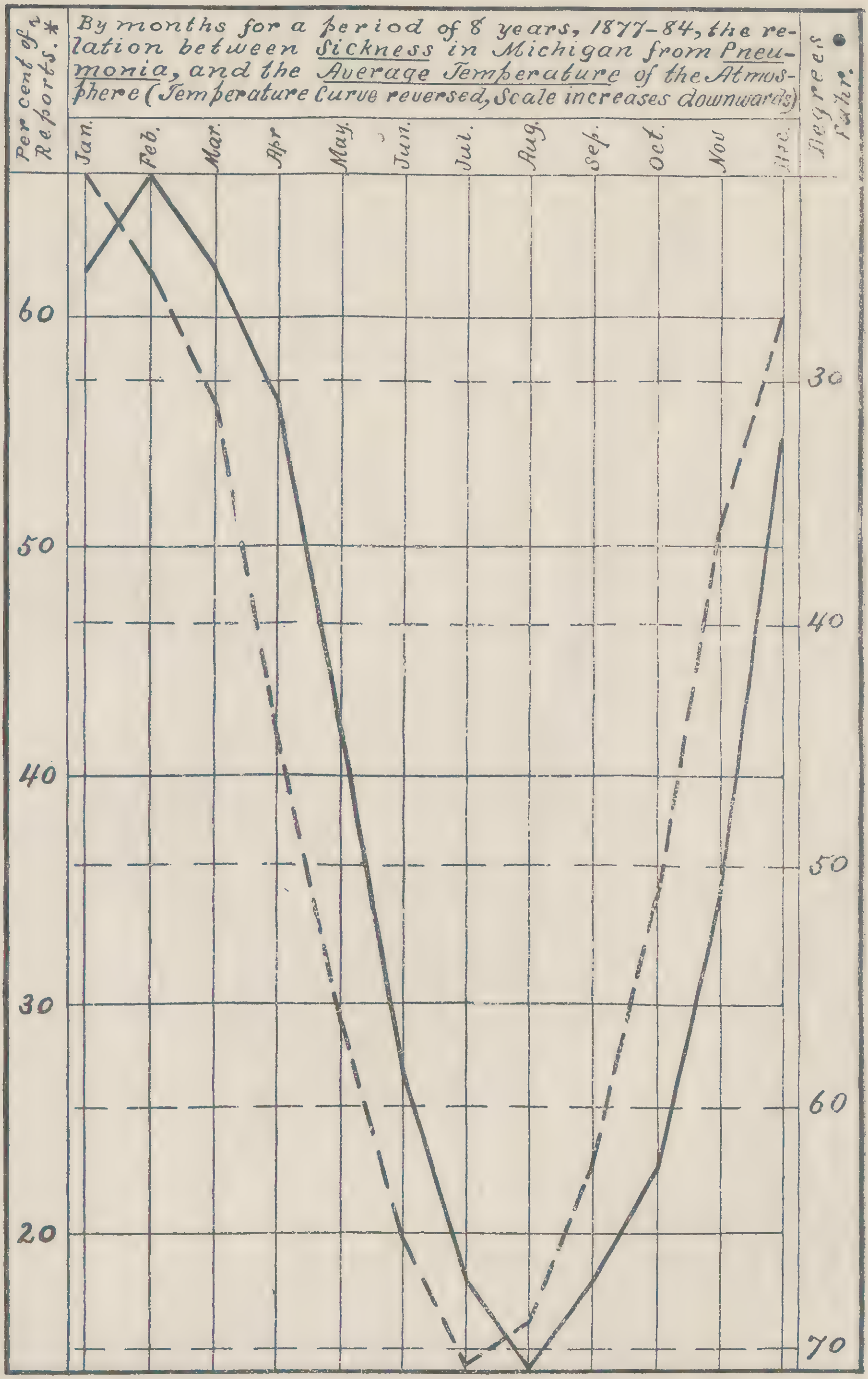


Bronchitis ———— . Average Temperature — — —.

* Indicating what per cent of all reports received, stated the presence of Bronchitis then under the observation of the physicians reporting.

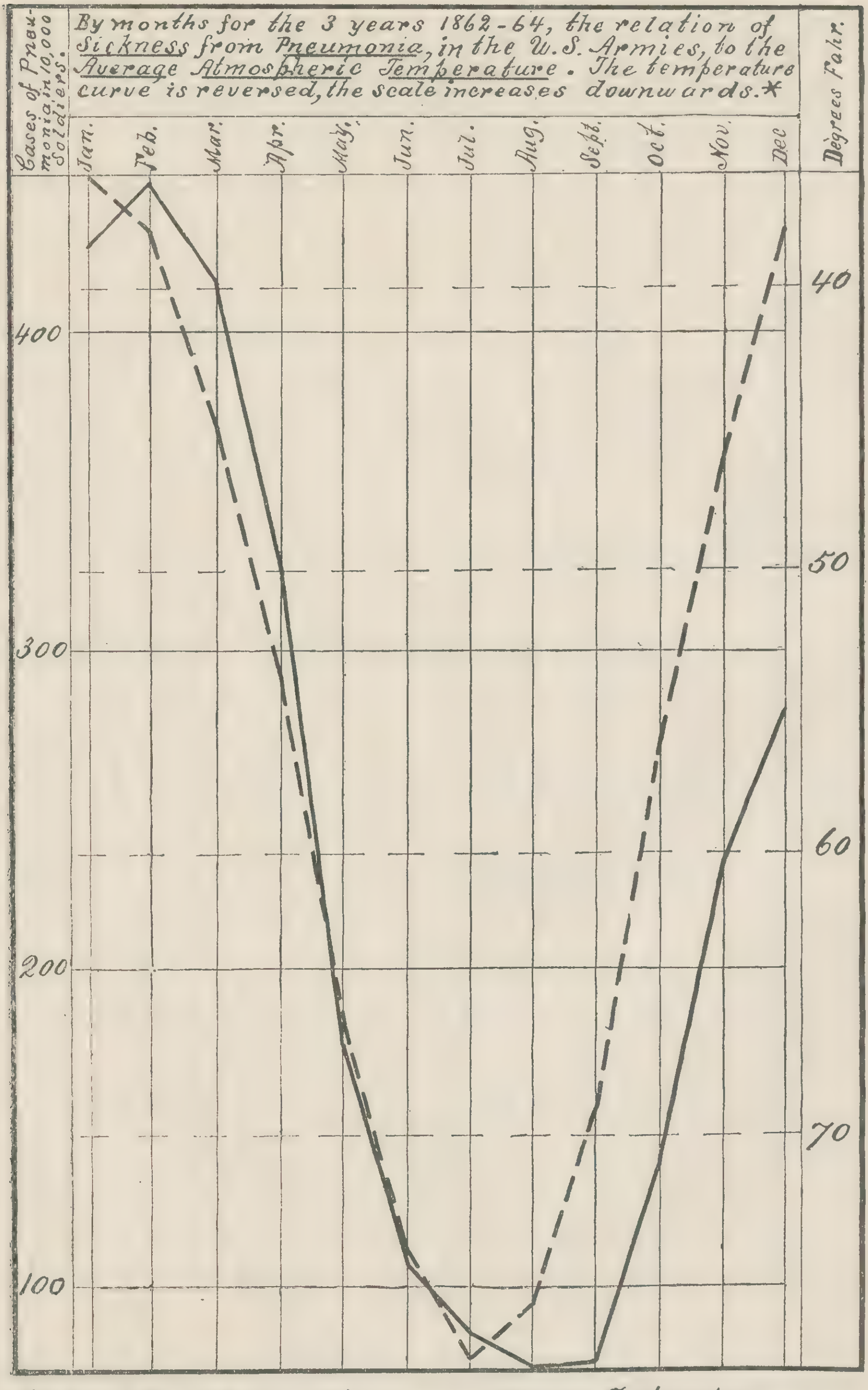
Over 35,000 weekly reports of sickness, and about 173,000 observations of the atmospheric temperature are represented in this diagram.

NO. 4.—TEMPERATURE, AND SICKNESS FROM PNEUMONIA IN MICHIGAN.



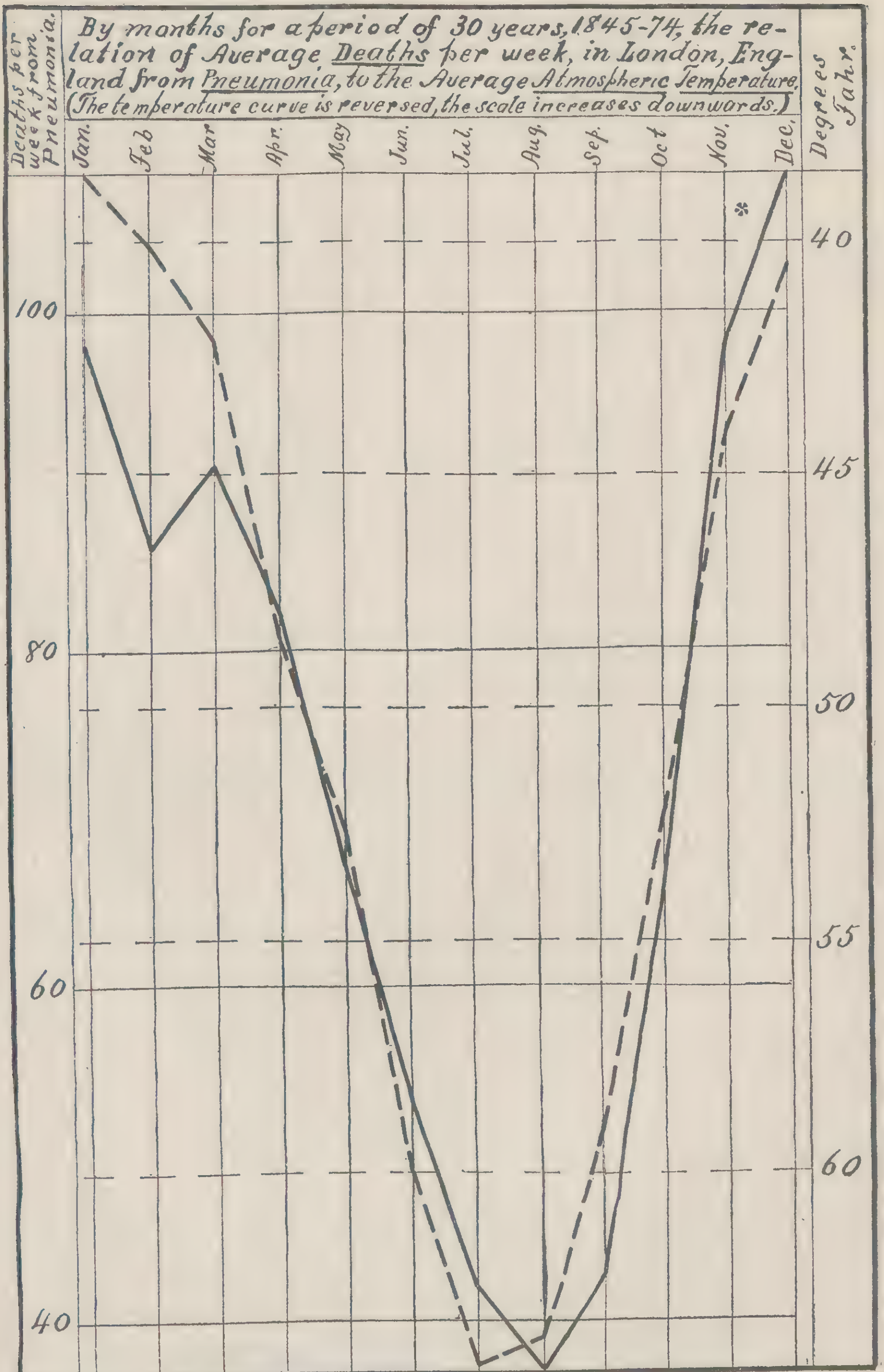
Sickness from Pneumonia ———. Average Temperature — —.
*Indicating what per cent of all reports received, stated the presence of pneumonia then under the observation of the physicians reporting.
• Over 30,000 weekly reports of sickness, and over 150,000 • observations of the atmospheric temperature are represented in this diagram.

NO. 5.—TEMPERATURE AND SICKNESS FROM PNEUMONIA IN U. S. ARMIES.



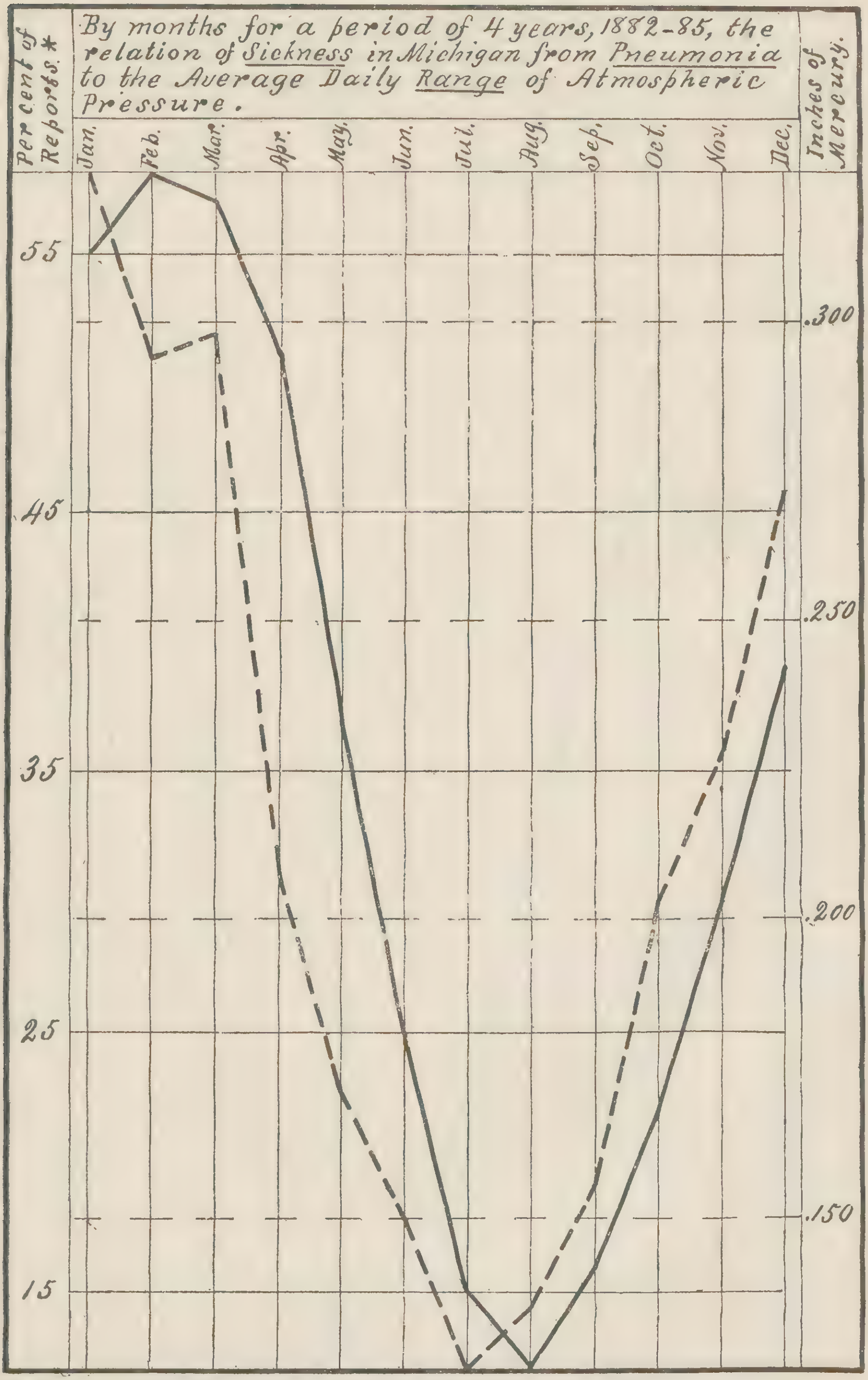
Sickness from Pneumonia ——— . Average Temperature — — —
* The temperature curve is made from the normals at six stations representing approximately the localities occupied by the armies of the United States.

NO. 6.—TEMPERATURE AND DEATHS FROM PNEUMONIA IN LONDON.

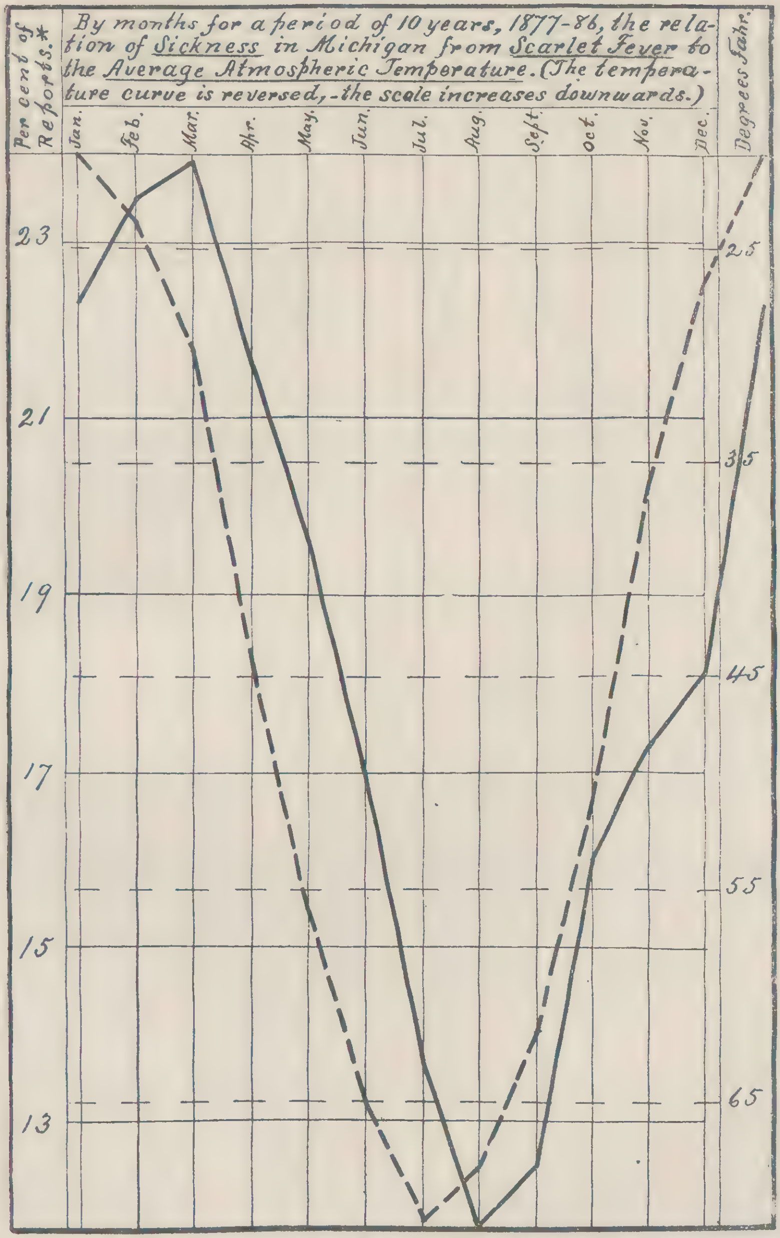


* Perhaps a greater proportion of deaths are returned for the later than for the earlier months in each year?

NO. 7.—DAILY RANGE OF BAROMETER, AND SICKNESS FROM PNEUMONIA.

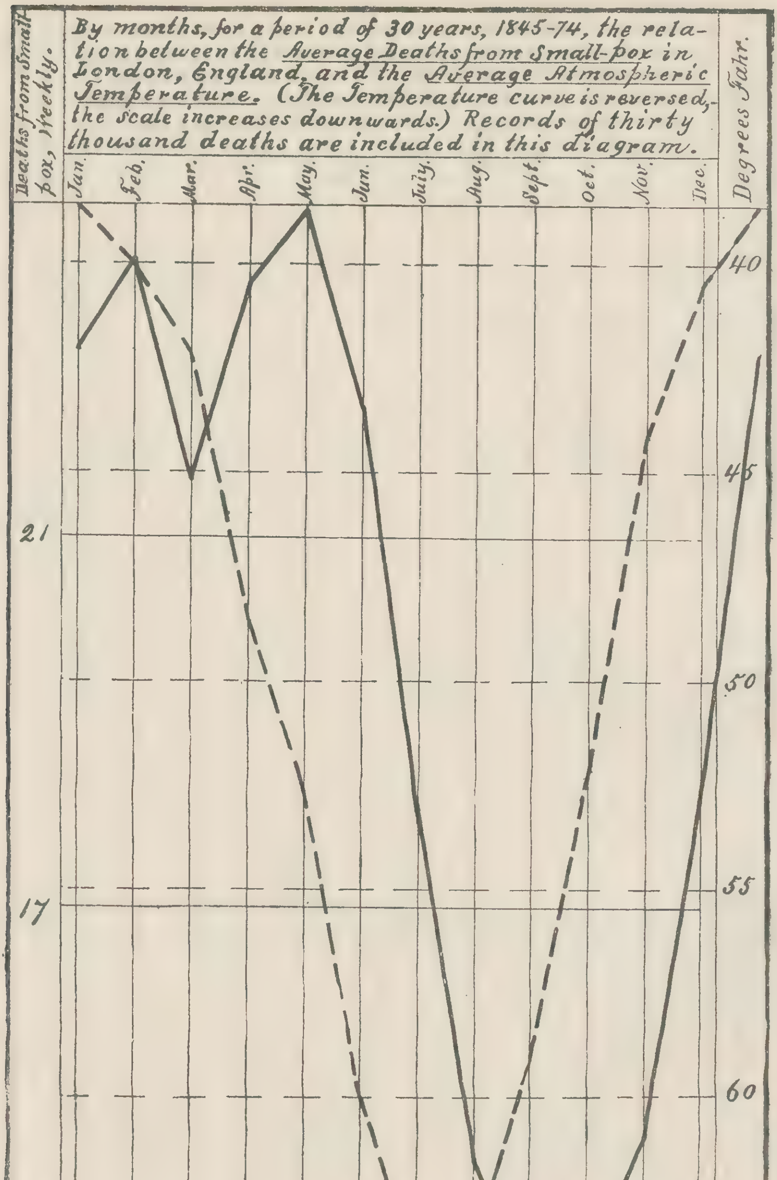


Sickness from Pneumonia ——. Av. daily range of Barometer — — —.
*Which stated that Pneumonia was under the observation of the physicians who made reports.



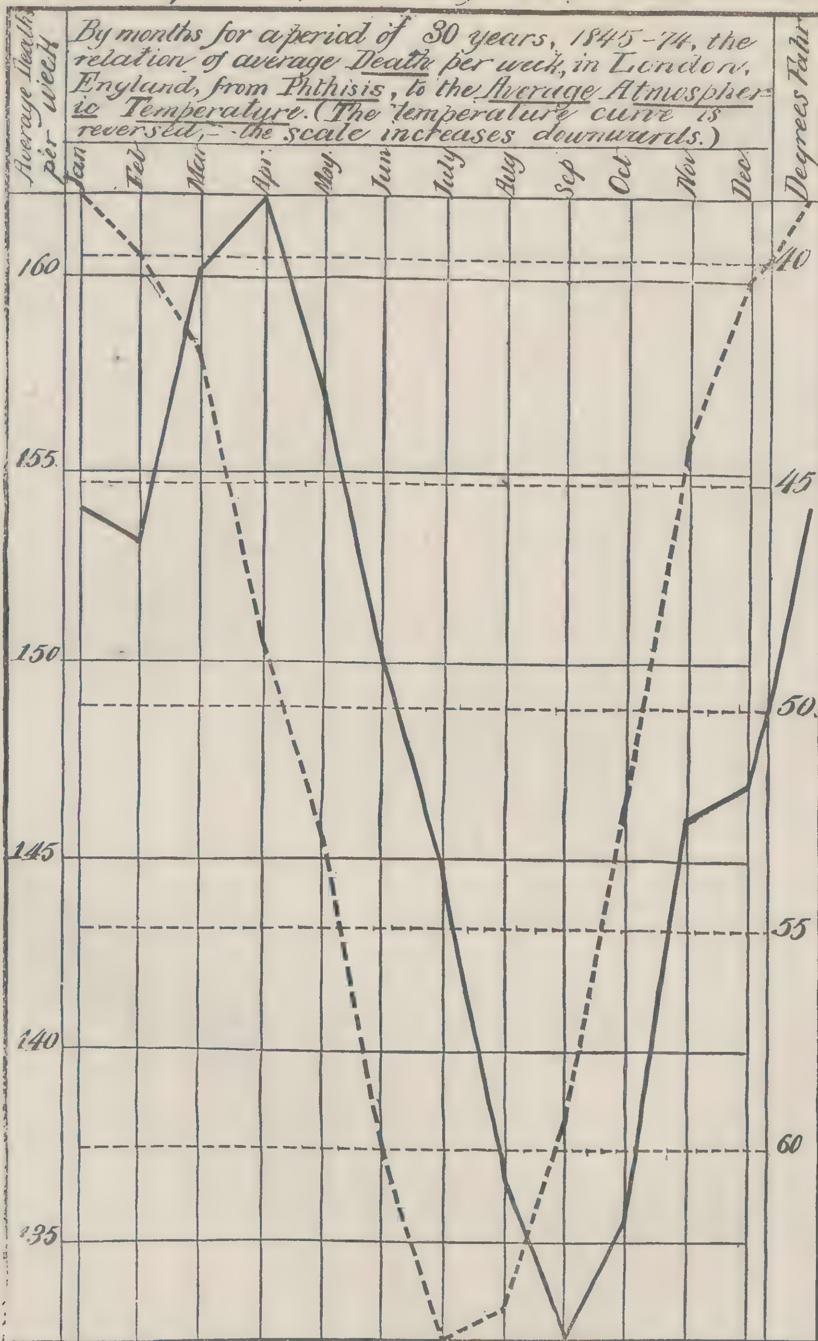
Scarlet Fever ————. Average Temperature — — —.
*Which stated that Scarlet Fever was under the observation of the physicians who made reports.
Over forty-one thousand weekly reports of sickness and over 190,000 observations of the atmospheric Temperature are represented in this diagram.

NO. 9.—TEMPERATURE, AND DEATHS FROM SMALL-POX IN LONDON.



Small-pox ———. Average Temperature — — —.
Except in a few months the Small-pox follows two months later than the temperature changes.
The line representing Small-pox should follow as long a time later than a line representing its controlling condition as is the average duration of the fatal cases plus the period of incubation?

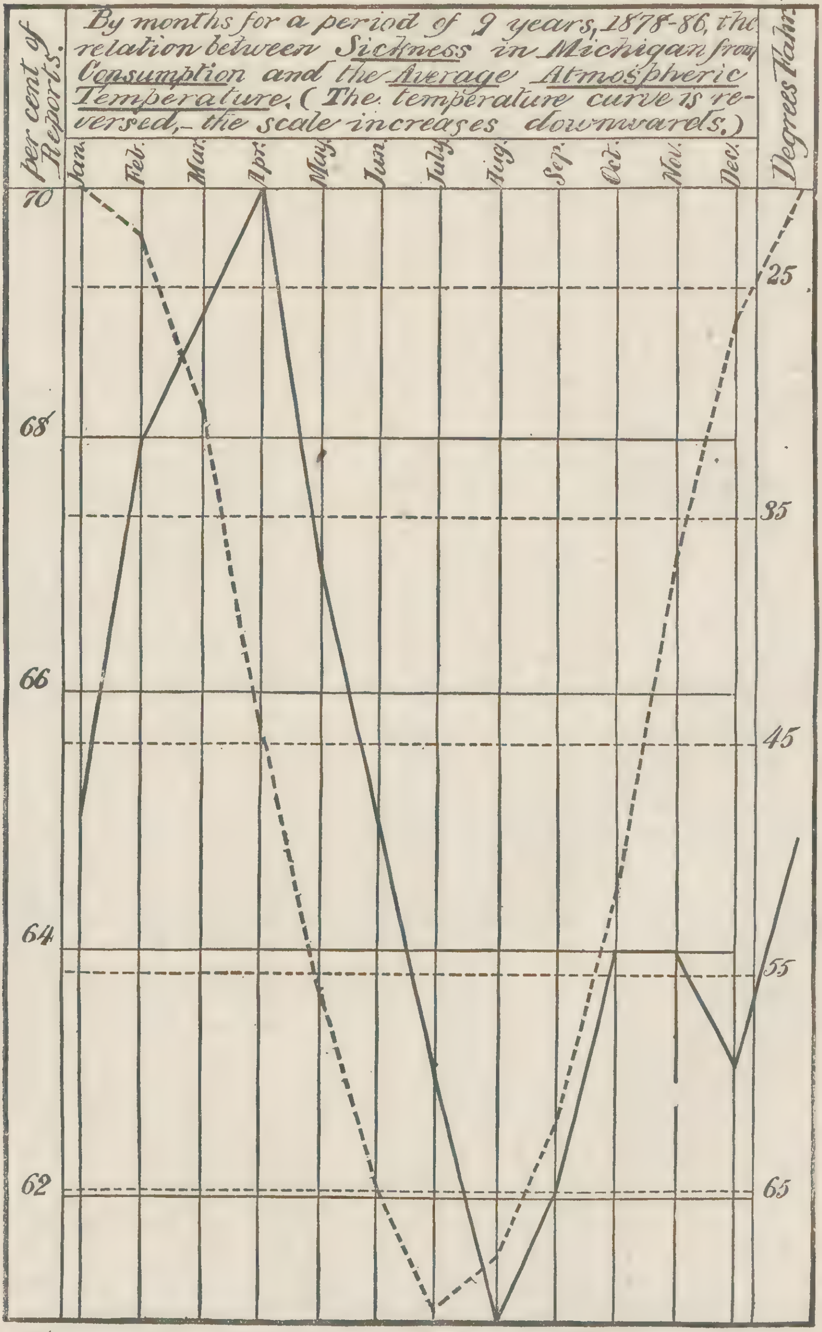
No 10— Temperature, and Deaths from Phthisis in London.



Deaths ———. Average Temperature - - - - - - - -

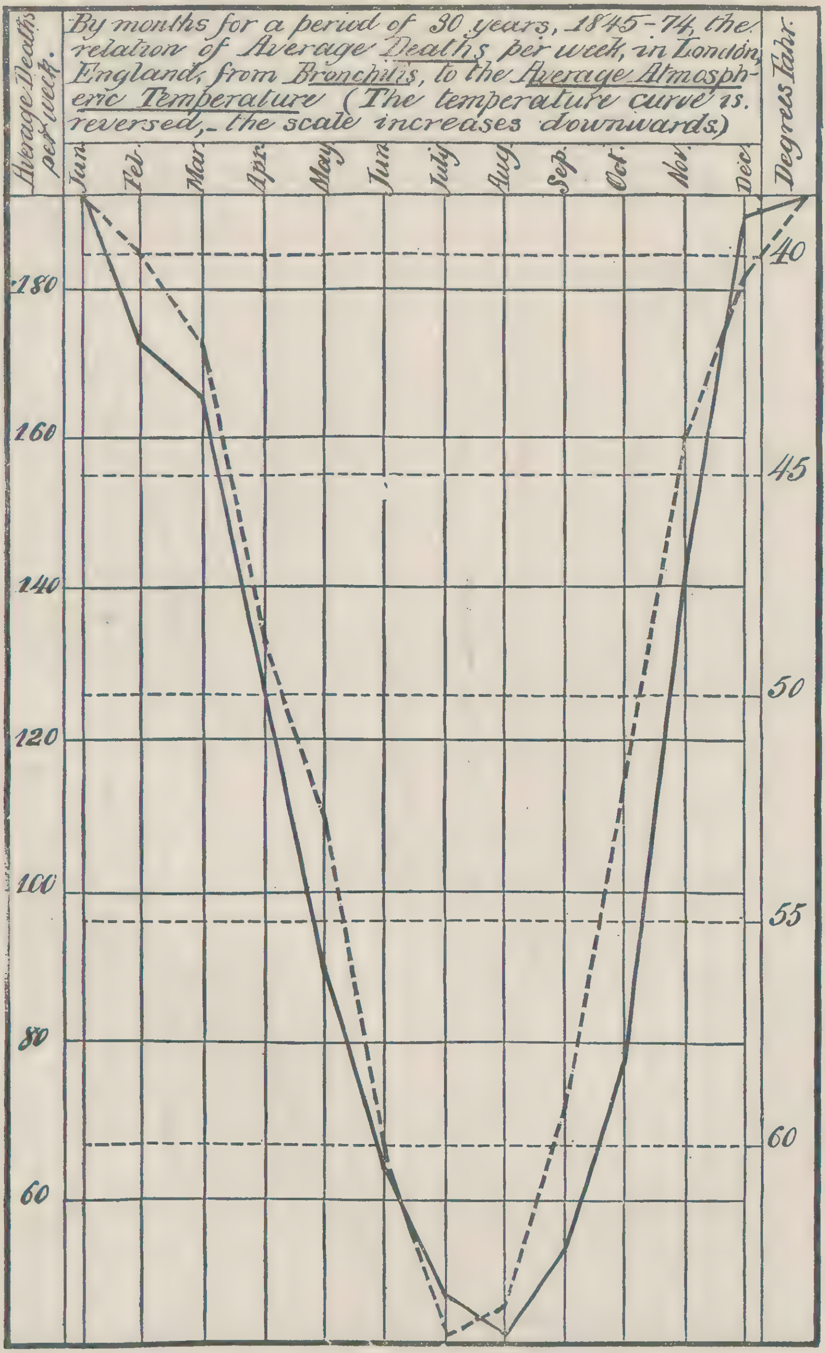
About 231.000 deaths from Phthisis are represented in this diagram data for which are from Jour. of Scottish Met. Soc., New Series Nos XLIII, XLIV, XLV, XLVI, pages 252 and 263.

No 11 Temperature and Sickness from Consumption in Michigan.



Consumption ——— Average Temperature – –

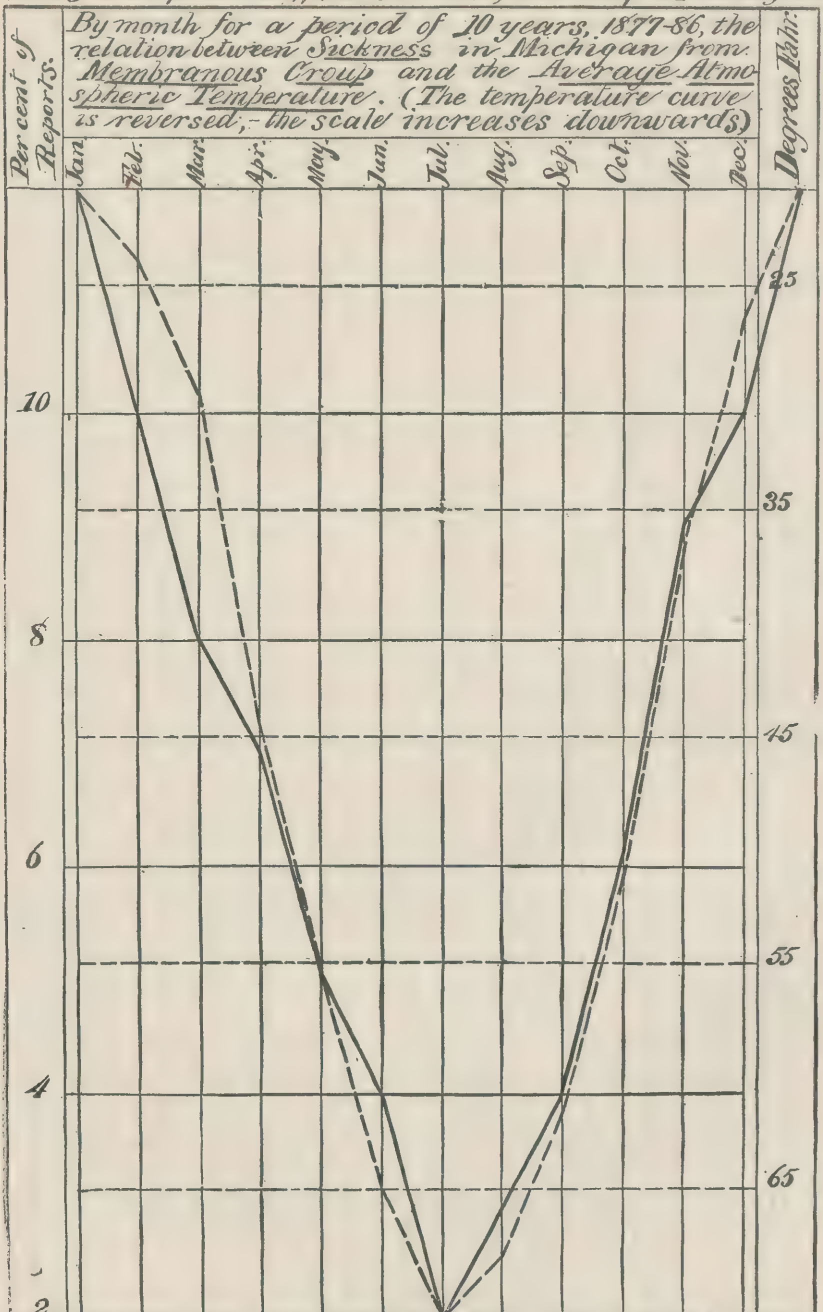
No 12.–Temperature and Deaths from Bronchitis in London.



Deaths ———— Average Temperature - - - - -

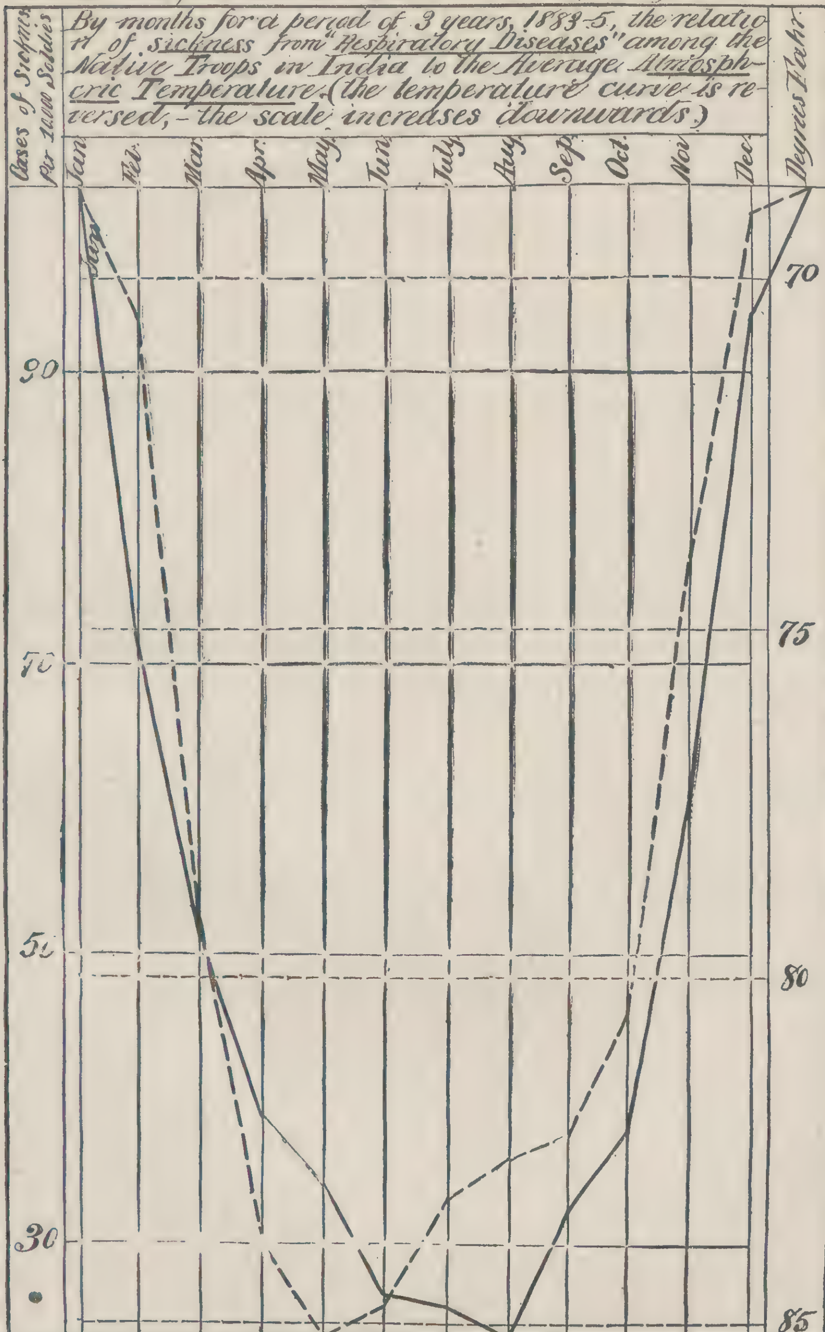
About 176,000 deaths from Bronchitis are represented in this diagram data for which are from Jour of Scottish Met. Soc. New Series Nos. XLIIII., XLIV., XLV., XLVI. pages 253 and 262

No 13 Temperature, and Sickness from Croup in Michigan



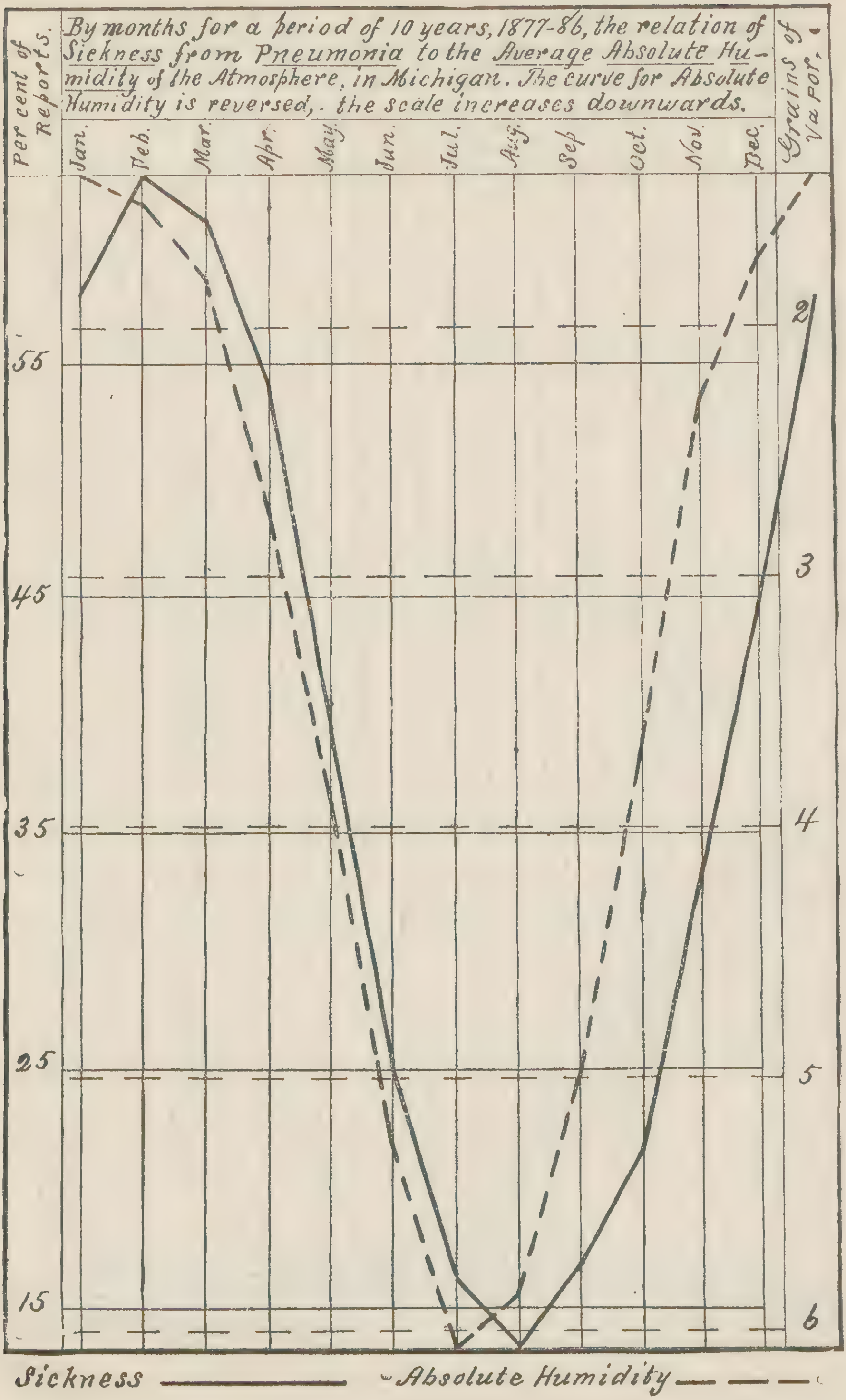
Membranous Croup ——— Average Temperature - - -

No 14 Temperature, and Sickness from "Respiratory Diseases" in India



Averag cases of sickness ____ Average Temperature - - - - -
Prepared from data found in 20th, 21st and 22nd Annual Reports of the Sanitary Commissioner with the Government in India.

NO. 15.—ABSOLUTE HUMIDITY, AND SICKNESS FROM PNEUMONIA IN MICHIGAN.



TEMPERATURE, AND SICKNESS FROM INFLUENZA IN MICHIGAN.

TABLE 1.—*Exhibiting, by months, for the ten years, 1877-1886, the average percentage of reports stating the presence of sickness from Influenza in Michigan, also the average atmospheric temperature at stations in Michigan for the same period of time.*

Ten years, 1877-1886.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Average percentage of reports of sickness	55	61	59	52	38	28	20	21	29	33	41	48
Av. temperature, deg. F.	20.56	23.62	29.80	44.33	56.08	65.10	70.52	68.14	61.67	50.83	36.04	26.60

Table 1 is graphically represented in Diagram 1.

TEMPERATURE, AND SICKNESS FROM TONSILITIS IN MICHIGAN.

TABLE 2.—*Exhibiting, by months, for the eight years, 1879-1886, the average percentage of reports stating the presence of sickness from Tonsilitis in Michigan, also the average atmospheric temperature at stations in Michigan, for the same period of time.*

Eight years, 1879-1886.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Average percentage of reports of sickness	60	61	60	53	47	42	33	32	37	45	55	60
Av. Temperature, deg. F.	19.91	21.77	28.82	43.04	55.98	64.79	69.78	66.25	61.11	50.68	35.56	25.82

Table 2 is graphically represented in Diagram 2.

TEMPERATURE, AND SICKNESS FROM BRONCHITIS IN MICHIGAN.

TABLE 3.—*Exhibiting, by months, for the nine years, 1877-1885, the average percentage of reports stating the presence of sickness from Bronchitis in Michigan, also the average atmospheric temperature at stations in Michigan, for the same period of time.*

Nine years, 1877-1885.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Average percentage of reports of sickness	77	78	77	72	61	54	43	41	49	55	67	72
Av. temperature, deg. F.	20.77	23.89	29.76	44.14	56.23	65.30	70.73	68.23	61.73	50.72	36.23	27.28

Table 3 is graphically represented in Diagram 3.

TEMPERATURE, AND SICKNESS FROM PNEUMONIA IN MICHIGAN.

TABLE 4.—*Exhibiting, by months, for the eight years, 1877-1884, the average percentage of reports stating the presence of sickness from Pneumonia in Michigan, also the average atmospheric temperature at stations in Michigan, for the same period of time.*

Eight years, 1877-1884.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	ug.	Sept.	Oct.	Nov.	Dec.
Average percentage of reports of sickness	62	66	62	56	42	27	17	14	18	23	36	48
Av. temperature, deg. F.	21.43	25.60	31.04	44.48	56.60	65.54	70.68	68.85	62.05	51.34	35.99	27.25

Table 4 is graphically represented in Diagram 4.

TEMPERATURE, AND SICKNESS FROM PNEUMONIA IN THE U. S. ARMIES.

TABLE 5.—*Exhibiting, by months, for a period of three years, 1862-1864, the sickness from Pneumonia in the U. S. Armies, also the average atmospheric temperature for the same period of time.*

Three years, 1862-1864.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct	Nov.	Dec.
Average number of cases of sickness from Pneumonia, per 10,000 soldiers	427	447	415	324	176	107	85	74	77	139	233	281
Av. temperature, deg. F.	36	38	45	54	66	74	78	76	69	56	46	38

Table 5 is graphically represented in Diagram 5.

TEMPERATURE, AND DEATHS FROM PNEUMONIA IN LONDON, ENGLAND.

TABLE 6.—*Exhibiting, by months, for the thirty years, 1845-1874, the average number of deaths from Pneumonia in London, England, also the average atmospheric temperature for the same period of time.*

Thirty years, 1845-1874.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Average deaths per week, from Pneumonia	98	86	91	82	67	53	42	37	43	66	98	108
Av. temperature, deg. F.	38.6	40.1	42.2	48.6	52.7	60.0	64.2	63.5	59.1	52.2	44.2	40.5

Table 6 is graphically represented in Diagram 6.

RANGE OF ATMOSPHERIC PRESSURE, AND SICKNESS FROM PNEUMONIA IN MICHIGAN.

TABLE 7.—*Exhibiting by months, for the four years, 1882-1885, the average percentage of reports stating the presence of sickness from Pneumonia in Michigan; also the average daily range of atmospheric pressure for the same period of time.*

Four years, 1882-85.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec.
Average percentage of reports of sickness	55	58	57	51	37	25	15	12	16	22	30	39
Average daily range of atmospheric pressure	.325	.294	.298	.208	.171	.150	.125	.136	.156	.203	.228	.272

Table 7 is graphically represented in Diagram 7.

TEMPERATURE, AND SICKNESS FROM SCARLET FEVER IN MICHIGAN.

TABLE 8.—*Exhibiting, by months, for a period of ten years, 1877-1886, the relation which the sickness in Michigan from Scarlet Fever sustained to the atmospheric temperature: Exhibiting the average atmospheric temperature, and what percentage of all weekly reports received stated that Scarlet Fever was under observation of the physicians who made the reports. (Over 41,000 weekly reports of sickness, and over 190,000 observations of the atmospheric temperature are represented in this table.)*

Ten years, 1877-86.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec.
Av. percentage of reports	22.3	23.5	23.9	21.6	19.6	17.0	13.7	11.8	12.5	16.0	17.3	18.1
Av. temperature, deg. F.	20.56	23.62	29.80	44.33	56.08	65.10	70.52	68.14	61.67	50.83	36.04	26.60

Table 8 is graphically represented in Diagram 8.

TEMPERATURE, AND DEATHS FROM SMALL-POX IN LONDON, ENGLAND.

TABLE 9.—*Exhibiting, by months, for thirty years, 1845-1874, the relation between the weekly average number of deaths from Small-pox, and the average atmospheric temperature, in London, England. Records of 30,000 deaths are included in this table.*

Thirty Years, 1845-1874.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. weekly No. of deaths	23.00	24.00	21.60	23.75	24.50	22.40	18.00	14.25	13.00	13.00	14.50	18.20
Av. temperature, degrees Fahr.	38.6	40.1	42.2	48.6	52.7	60.0	64.2	63.5	59.1	52.2	44.2	40.5

Table 9 is graphically represented in Diagram 9.

TEMPERATURE, AND DEATHS FROM PHTHISIS IN LONDON, ENGLAND.

TABLE 10.—*Exhibiting, by months, for a period of thirty years, 1845-1874, the relation of average deaths per week, in London, England, from Phthisis, to the average atmospheric temperature for the same period of time.*

Thirty Years, 1845-1874.	Jan.	Feb.	Mar.	Apr l.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. deaths per week from Phthisis	154	153.25	160.2	162	157.25	150	144.75	136.50	132.4	135.75	146	147
Av. temperature, degrees Fahr.	38.6	40.1	42 2	48.6	52.7	60.0	64.2	63.5	59.1	52.2	44.2	40.5

Table 10 is graphically represented in Diagram 10.

TEMPERATURE, AND SICKNESS FROM CONSUMPTION IN MICHIGAN.

TABLE 11.—*Exhibiting, by months, for a period of nine years, 1878-1886, the relation between sickness in Michigan from Consumption, and the average atmospheric temperature for the same period of time.*

Nine Years, 1878-86.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. percentage of reports of sickness	65	68	69	70	67	65	63	61	62	64	64	63
Av. temperature, degrees Fahr.	20.72	22.68	30.23	44.06	55.84	64.83	70.27	67.88	61.43	35.87	35.87	25.47

Table 11 is graphically represented in Diagram 11.

TEMPERATURE, AND DEATHS FROM BRONCHITIS IN LONDON.

TABLE 12.—*Exhibiting, by months, for a period of thirty years, 1845-1874, the relation of average deaths per week in London, England, from Bronchitis, to the average atmospheric temperature for the same period of time.*

Thirty Years, 1845-74.	Jan.	Feb.	Mar.	April.	Ma y	June.	July.	Aug.	Sept.	Oct.	Nov.	ec.
Av. deaths per week from Bronchitis	193.5	172.5	165.	127.5	90.0	63.2	48.25	41.0	48.2	76.5	141.25	190.2
Av. temperature, degrees Fahr.	38.6	40.1	42.2	48.6	52.7	60.0	64.2	63.5	59.1	52.2	44.2	40.5

Table 12 is graphically represented in Diagram 12.

TEMPERATURE, AND SICKNESS FROM CROUP IN MICHIGAN.

TABLE 13.—*Exhibiting, by months, for a period of ten years, 1877-86, the relation between sickness in Michigan from Membranous Croup, and the average atmospheric temperature for the same period of time.*

Ten Years, 1877-86.	Jan.	eb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. percentage of reports of sickness	2	10	8	7	5	4	2	3	4	6	9	10
Av. temperature, degrees Fahr.	20.56	23.62	29.80	44.33	56.08	65.10	70.52	68.14	61.67	50.83	36.04	26.60

Table 13 is graphically represented in Diagram 13.

TEMPERATURE, AND SICKNESS FROM "RESPIRATORY DISEASES" IN INDIA.

TABLE 14.—*Exhibiting, by months, for a period of three years, 1883-5, the relation of sickness from "Respiratory Diseases," among the native troops in India to the average atmospheric temperature for the same period of time.*

Three Years, 1883-5.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. cases of sickness per 10,000 soldiers	102.8	71.6	51.8	38.6	33.8	26.6	25.5	23.7	31.8	37.7	59.9	93.8
Av. temperature, degrees Fahr.	68.7	70.6	79.1	83.9	85.2	84.8	83.3	82.7	82.3	80.5	74.2	69.1

Table 14 is graphically represented in Diagram 14.

ABSOLUTE ATMOSPHERIC HUMIDITY, AND SICKNESS FROM PNEUMONIA IN MICHIGAN.

TABLE 15.—*Exhibiting, by months, for a period of ten years, 1877-86, the relation of sickness in Michigan from Pneumonia, to the average absolute humidity.*

Ten Years, 1877-86.	Annual Av.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Sickness from Pneumonia	36.5	57.9	63.1	61.1	53.9	39.3	25.1	16.1	13.3	16.7	21.3	33.4	44.8
Average Absolute Humidity	3.44	1.38	1.51	1.81	2.75	3.91	5.27	6.07	5.84	4.98	3.71	2.30	1.73

The two lines in Table 15 are graphically represented in Diagram No. 15. This table and the diagram were not published, with this paper, in the Trans. of the International Congress, but have been added to it here in order to show how closely the inflammation of the lungs follows the rise and fall of the atmospheric humidity,—the greater the humidity the less the sickness, being the rule.